17 June 1966

CA-19712

Headquarters, Logistical Support Group (Provisional)
Headquarters Command
United States Air Force
Bolling Air Force Base, D. C. 20332

Attention: [redacted]

Subject: Quotation for AP-3 Computer Programming Services

Gentlemen:

In response to your discussions with our [redacted] is pleased to submit a proposal for programming services for the AP-3 computer consisting of this letter and the attached Technical Description.

Because of the variety of possible approaches to the proposed programming tasks, we have divided our proposal into two parts for present quotation purposes: Item 1 - Engineering Study, and Item 2 - Programming Services. The engineering study is primarily an investigation of alternative approaches to programming the AP-3 computer to handle strip photography with the required precision and range of input variables. The result of the study would be an informal written report containing specifications and preliminary flow charts for the recommended approach to operational programs for strip photography. Item 2, Programming Services, would cover the actual programming effort to implement the programs recommended as a result of performing Item 1. The results of Item 2 would be operational programs complete with formal descriptive documentation and operating instructions.

25X [redacted]

Hqtrs., Logistical Support Group (Provisional)

17 June 1966
CA-19712

X1 [redacted]

We offer to provide the Engineering Study, Item 1, for a firm fixed-price
X1 [redacted] The study would be completed and the written report submitted within ninety (90) days after receipt and acceptance of contract. Terms are net 30 days. This quotation will remain valid for a period of sixty (60) days from the date of this letter. An Analysis of Estimated Cost is attached for Item 1 which provides a cost breakdown.

Our budgetary estimate for Item 2 is [redacted] Delivery is currently 25X
estimated as nine (9) months after receipt and acceptance of contract for Item 2. A firm price and delivery quotation would be submitted at approximately the completion date for the Item 1 effort.

We look forward to hearing from you with regard to this proposal. In
X1 any negotiation, [redacted] would be represented by the undersigned. The telephone contact is area code
X1 [redacted], Contracts
X1 Administrator, [redacted] Should you desire additional information, please do not hesitate to contact us.

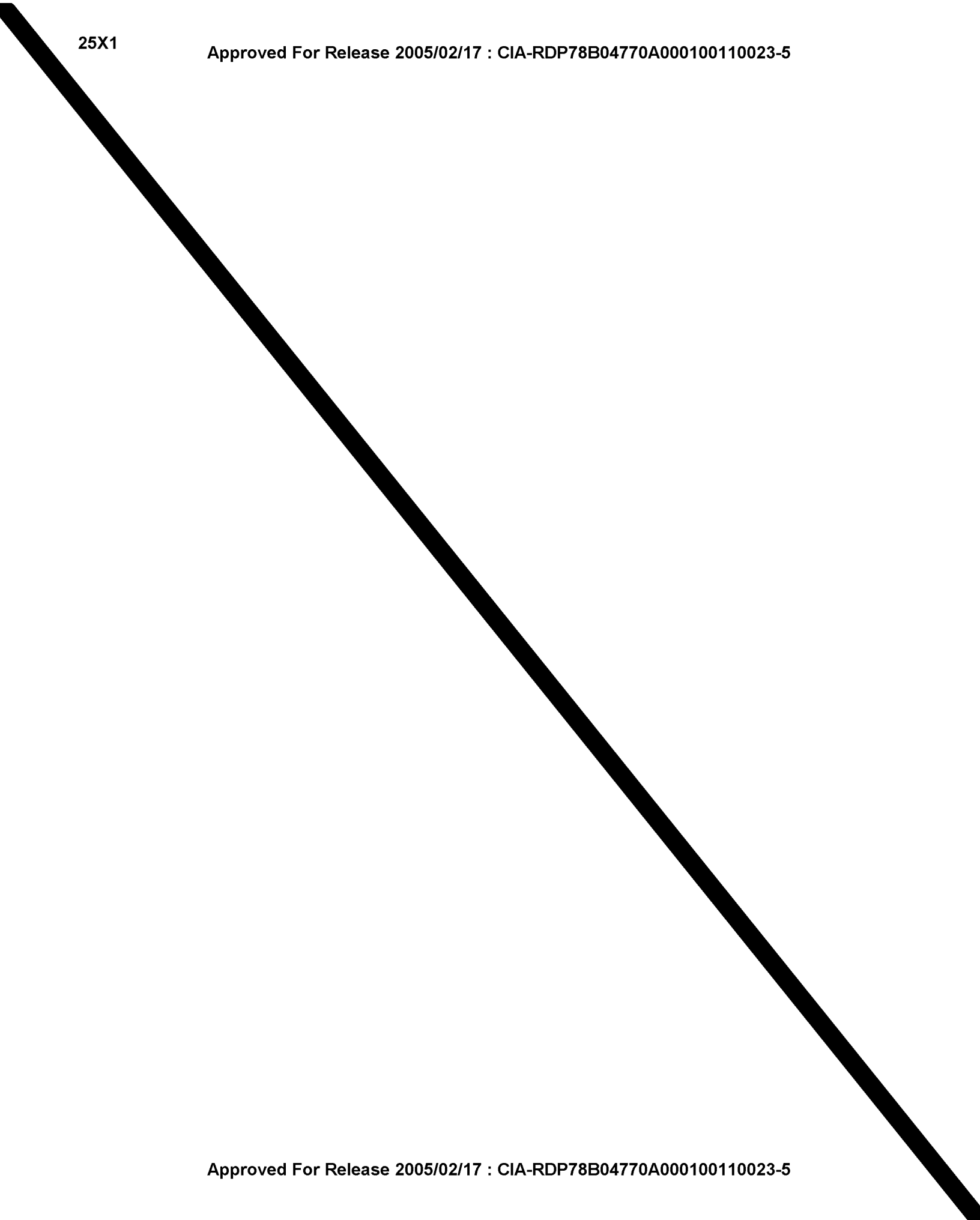
Very truly yours,

25X [redacted]

General Manager and Director

ECJ/ea

Attachment: Item 1 - Analysis of Estimated Gost
Technical Description



Approved For Release 2005/02/17 : CIA-RDP78B04770A000100110023-5

17 June 1966
CA
Attachment

TECHNICAL DESCRIPTION OF ENGINEERING STUDY AND PROGRAMMING SERVICES

1 INTRODUCTION

This attachment describes the scope of effort for Item 1, Engineering Study, and the detailed equations to be programmed under Item 2, Programming Services. Although the contemplated ranges of input variables, high precision, and desired slewing speed for the strip photography programs impose computational requirements beyond those for which the AP-3 computer was designed, it appears to be feasible to program the AP-3 to solve the required equations if careful compromises are made in certain parameters. Some changes in general operating procedures may also be necessary. Possible programming approaches are discussed in the following section.

2 ENGINEERING STUDY

The purpose of the Engineering Study is to formulate several possible programming approaches, define trade-off possibilities, and determine the most satisfactory approach to programming the AP-3 for strip photography. The combination of large ranges of input parameters and very high precision are difficult to implement within the limitations of the existing AP-3 incremental section. If the equations were solved entirely in the incremental section, definite compromises would be necessary in slewing speed and in allowable combinations of focal length and film format. Typical alternate approaches to be considered include:

1. Devising a method of double-precision incremental-section programming.

Attachment
CA

2. Using the whole-number section to assist the incremental section in those portions of the problem where precision is of most critical importance.

3. Allowing the incremental section to solve the problem with moderate accuracy at a rate of 100 solutions per second (as in present AP-3 programs); updating the solutions with high-precision whole-number calculations at a lower rate of one to two solutions per second.

The key steps in the Engineering Study would be:

1. Define critical parameter ranges.

2. Define the parameter ranges that are desirable but not critical.

3. Differentiate between essential, desirable, and unnecessary operational features.

4. Investigate alternate programming approaches and evaluate each in view of operational requirements.

5. Discuss any trade-offs with user's personnel and agree on best approach.

6. Submit informal report.

The above procedure would assure the selection of an approach to the strip-photography programs which is both practicable and best suited to the user's operational needs.

Attachment
CA

3 PROGRAMMING SERVICES

The proposed programming services would include the development of programs to accomodate strip photography with extended camera focal lengths and formats up to 9 by 9 inches. The programs would provide for operation with a resolution of either 5 or 1-1/4 microns. The operation of the strip-photography programs would be substantially the same as that of existing frame programs except that both slewing speed and "look angle" may be substantially reduced for long-focal-length photography, where look angle is defined as one-half of the included camera lens angle.

The AP-3 computer programs for strip photography would be capable of handling the following ranges of input variables:

Parameter	Range
ϕ	$0 \pm 20^{\circ}$
w	$0 \pm 45^{\circ}$
k	$0 \pm 10^{\circ}$

The ranges for other inputs would be the same as in the existing frame programs, except that the focal length range would be increased.

3.1 Required Input Data

The equations given in Sections 3.2 and 3.3 assume that each strip photograph of the stereo pair has undergone a preliminary off-line analysis, resulting in the following input data:

1. Strip-photo x, y coordinates of two or more marked photo points on each photo for interior orientation for both photo 1 and photo 2. These need not be conjugate points.

2. Exposure station coordinates b_{xo}, b_{yo}, b_{zo} for each photo, referenced at x' = y' = 0.

3. Phi, omega, kappa for each photo.

4. Film velocity, v_f, for each photo, known as a function of t, where t is taken as zero at x' = y' = 0.

5. Ground-velocity components V_x, V_y, V_z for each photo. These components are considered to be constant.

6. Some of the usual frame photography constants: F, R, $\bar{Y}$, C_h, C_e, model-distortion coefficients, lens distortion coefficients.

3.2 Preliminary Calculations

The following preliminary calculations must be made before real-time operation can begin.

3.2.1 Interior Orientation

The x, y plotter coordinate system must be referred to the x', y' coordinate system of the strip photo. For each photo, two or more photo points marked by PUG or other point-transfer device are required to solve the equations

$$x = Ax' + By' + C_1$$

$$y = -Bx' + Ay' + C_2$$

where $A^2 + B^2 = 1$.

The constants A, B, C_1 and C_2 would be determined for each photo by the whole-number section of the computer.

Attachment
CA

The equations for solution with n reference points are:

$$A = \frac{\sum_{i=1}^{n} (x'_i - x'_1)(x_i - x_1) + \sum_{i=1}^{n} (y'_i - y'_1)(y_i - y_1)}{\sum_{i=1}^{n} (x'_i - x'_1)(x'_i - x'_1) + \sum_{i=1}^{n} (y'_i - y'_1)(y'_i - y'_1)}$$

$$B = \frac{\sum_{i=1}^{n} (x_i - x_1)(y'_1 - y'_1) - \sum_{i=1}^{n} (x'_i - x'_1)(y_i - y_1)}{\sum_{i=1}^{n} (x'_i - x'_1)(x'_i - x'_1) + \sum_{i=1}^{n} (y'_i - y'_1)(y'_i - y'_1)}$$

$$C_1 = \sum_{i=1}^{n} (x_i - x_1) - A\sum_{i=1}^{n} (x'_i - x'_1) - B\sum_{i=1}^{n} (y'_i - y'_1)$$

$$C_2 = \sum_{i=1}^{n} (y_i - y_1) + B\sum_{i=1}^{n} (x'_i - x'_1) - A\sum_{i=1}^{n} (y'_i - y_1$$

3.2.2 X''' Component of Ground Velocity

The ground velocity vector must be referred to the photo x' coordinate direction by the following rotation:

$$V'_x = V_x \cos k + V_y \sin k$$

$$V'_y = -V_x \sin k + V_y \cos k$$

$$V'_z = V_z$$

$$V''_x = V'_x$$

$$V''_z = V'_y \sin w + V'_z \cos w$$

$$V'''_x = V''_x \cos \phi \quad -V''_z \sin \phi$$

3.3 Real-Time Calculations

The AP-3 would be programmed to make the following real-time calculations:

3.3.1 Corrections for Model Distortion

$$P_x = a_1 X_m + a_2 Y_m + a_3 X_m^2 + a_4 X_m Y_m + a_5 Y_m^2 + a_6 X_m^3 + a_7 X_m^2 Y_m + a_8 X_m Y_m^2 + a_9 Y_m^3$$

$$P_y = b_1 X_m + b_2 Y_m + \text{---} + b_9 Y_m^3$$

$$P_z = c_1 X_m + c_2 Y_m + \text{---} + c_9 Y_m^3$$

3.3.2 Earth Curvature Corrections

$$\Delta Y_c = -\frac{1}{6R^2} [Y_m^* - \bar{Y}]^3$$

$$\Delta Z_c = -\frac{1}{2R} [Y_m^* - \bar{Y}]^2$$

3.3.3 Correction Summing

$$X_m^* = X_m + P_x$$

$$Y_m^* = Y_m + P_y \qquad \bar{Y}_m^* = Y_m^* + \Delta Y_c$$

$$Z_m = E_m + P_z + \Delta Z_c$$

Attachment
CA

3.3.4 Corrections for Atmospheric Refraction

$$E_m = C_h C_e e^{-C_e E_m} \frac{(Y_m^* - b_y)^2}{(b_z - Z_m)^2}$$

3.3.5 Exposure Station Adjustment

$$b_y = b_{yo} + V_y t$$

$$b_z = b_{zo} + V_z t$$

3.3.6 Coordinate Translation

$$X_c = X_m^* - b_{xo}$$

$$Y_c = Y_m^* - b_{yo}$$

$$Z_c = Z_m - b_{zo} + \Delta E_m$$

3.3.7 Coordinate Rotation

$$X' = X_c \cos k + Y_c \sin k$$

$$Y' = -X_c \sin k + Y_c \cos k$$

$$Z' = Z_c$$

$$X'' = X'$$

$$Y'' = Y' \cos w + Z' \sin w$$

$$Z'' = -Y' \sin w + Z' \cos w$$

Attachment
CA

$$X''' = X'' \cos \phi \; - Z'' \sin \phi$$

$$Y''' = Y''$$

$$Z''' = X'' \sin \phi + Z'' \cos \phi$$

3.3.8 Film Speed Correction

$$v_f = F(t)$$

3.3.9 Scaling

$$y'' = -\frac{F}{Z'''} Y'''$$

$$t = \frac{X'''_o}{V'''_x}$$

$$x'' = v_f t$$

3.3.10 Lens Distortion and Film Shrinkage Corrections

$$\Delta y_L = F(y') \cong F(y'')$$

$$\Delta y_f = y'' C_f$$

3.3.11 Photo Point Corrections

$$y' = y'' + \Delta y_L + \Delta y_f$$

$$x' = x''$$

3.3.12 Interior Orientation Adjustment

$$x = Ax' + By' + C_1 \qquad \text{where } A^2 + B^2 = 1$$

$$y = -Bx' + Ay' + C_2$$

3.3.13 Magnification

$$\frac{M_o}{M} = \frac{Z'''^2}{F}$$